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Training system device certification and qualification process

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THESIS

TRAINING SYSTEM DEVICE CERTIFICATION AND QUALIFICATION PROCESS

by

Matthew D. Everson

September 2013

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Training system devices are frequently used for aviation training to prepare students to fly aircraft. The use of training systems can be used to reduce the number of flight hours required for pilots and aircrew. The aviation training system device must be designed properly to ensure that necessary learning objectives are met.

Certification is the last step in the test and evaluation process during the validation phase, within the systems engineering process, that ensures the system works as it was intended, and meets the user's need. Training System certification ensures the user that the training device can be used to properly meet certain learning objectives prior to flying.

This thesis analyzes existing training system device certification processes and provides recommendations to the United States Navy, Naval Air Warfare Center Training Systems Division, for improvements.

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TRAINING SYSTEM DEVICE CERTIFICATION AND QUALIFICATION PROCESS

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requirements for the degree of

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ABSTRACT

Training system devices are frequently used for aviation training to prepare students to fly aircraft. The use of training systems can be used to reduce the number of flight hours required for pilots and aircrew. The aviation training system device must be designed properly to ensure that necessary learning objectives are met.

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LIST OF ACRONYMS AND ABBREVIATIONS

AC	Advisory Circular
AETC	Air Education and Training Command
AFCFM	Air Force Career Field Managers
AFI	Air Force Instruction
AFMC	Air Force Material Command
AFPD	Air Force Policy Directive
AFSPC	Air Force Space Command
ANG	Air National Guard
AR	Army Regulation
ATD	Aircrew Training Device
ATG	Approved Test Guide
BCS	Baseline Comparative System
CAF	Combat Air Forces
CDD	Capability Design Document
CDR	Critical Design Review
CFR	Code of Federal Regulations
CNAF	Commander, Naval Air Forces
Comms	Communications
CONOPS	Concept of Operations
C2	Command and Control
DAG	Defense Acquisition Guidebook
DMO	Distributed Missions Office
DoD	Department of Defense
DoDD	Department of Defense Directive
DoDI	Department of Defense Instruction
DON	Department of the Navy
DOT	Department of Transportation

EESM	Event Essential Subsystems Matrix
ET	Embedded Training
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FEA	Front End Analysis
FPT	Fleet Project Team
FSTD	Flight Simulation Training Devices
FTD	Flight Training Device
GPO	Government Printing Office
ICD	Interface Control Document
ICS	Intercommunications System
INCOSE	International Council of Systems Engineering
IPT	Integrated Product Team
ISD	Instructional Systems Development
ISEO	In-Service Engineering Office
KSAs	Knowledge, Skills, and Attributes
LC	Lead Command
LO	Learning Objective
MATG	Master Approval Test Guide
MCT	Marine Combat Training
METL	Mission Essential Task List
MIL-HDBK	Military Handbook
MIL-PRF	Military Performance
MIL-STD	Military Standard
M&S	Modeling and Simulation

NASA	National Aeronautics and Space Administration
NATOPS	Naval Air Training and Operating Procedures Standardization
NAVAIR	Naval Air Systems Command
NAVAIRINST	Naval Air Systems Command Instruction
NAVMC	Navy, Marine Corps
NAWCTSD	Naval Air Warfare Center Training Systems Division
NFO	Naval Flight Officer
NSP	National Simulator Program
NSPM	National Simulator Program Manager
NTA	Navy Tactical Task
OFT	Operational Flight Trainer
OPNAV	Chief of Naval Operations
OPNAVINST	Chief of Naval Operations Instruction
PDR	Preliminary Design Review
POE	Projected Operational Environment
POI	Principle Operator Inspector
PTT	Part Task Trainer
RFP	Request for Proposal
ROC	Required Operational Capabilities
RTVM	Requirements Traceability Verification Matrix
SCS	Ship Control System
SE	Systems Engineering
SECNAV	Secretary of the Navy
SECNAVINST	Secretary of the Navy Instruction
SEP	Systems Engineering Plan
SETR	Systems Engineering Technical Review
SIMCERT	Simulator Certification
SIMVAL	Simulator Validation

SME	Subject Matter Expert
SoS	System of Systems
SOW	Statement of Work
SPEC	Specification
SRR-I	Systems Requirements Review One
SRR-II	Systems Requirements Review Two
STAO	Space Training Acquisition Office
START	Systematic Team Assessment of Readiness Training
STP	System Training Plan
TADSS	Training Aids, Devices, Simulators, and Simulations
TD	Training Device
TDCAP	Training Device Certification Accreditation Process
T&E	Test and Evaluation
TEMP	Test and Evaluation Master Plan
TES	Tactical Engagement Simulation
TPM	Training Pipeline Managers
T&R	Training and Readiness
TRR	Test Readiness Review
TS	Training System
TSSC	Training System Support Center
TVC	Type Verification Control
TYCOM	Type Commander
UC	User Command
UMFO	Undergraduate Military Flight Officer
USA	United States Army
USAF	United States Air Force
USMC	United States Marine Corps
USN	United States Navy
U&TW	Utilization and Training Workshop

V&V	Verification and Validation
VV&A	Verification, Validation, and Accreditation
VV&C	Verification, Validation, and Certification

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EXECUTIVE SUMMARY

This research describes and analyzes existing certification or qualification guidance for aviation training system devices. Aviation training system devices are used to help prepare and train for aircraft flying. The rising cost of fuel, the critical skills required for flying, and the cost of new training systems devices are presenting an opportunity for Naval Air Warfare Center Training Systems Division (NAWCTSD) to examine its certification and qualification process for aviation training systems.

To ensure the systems can be used properly to meet the original learning objectives for the pilot or aircrew, the system must be designed and tested properly to ensure it meets the user's goals and needs. There are several systems engineering methods that can be used to ensure the final training system device meets the original design intent. Training System certification, as a stage in the systems engineering process, ensures the user that the training device can be used to properly meet certain learning objectives prior to or substitution for actual flying.

This thesis begins with a top-level data analysis of the different guidance available for training system management and training system certification. All of the military organizations' guidance is directly linked to the Department of Defense Instruction 5000.02 (DoDI 5000.02), *Operation of the Defense Acquisition System*. The Federal Aviation Administration (FAA) qualification process is traceable back to the Title 14 Code of Federal Regulations (CFR) requirements. Ultimately, all the training device certification or qualification guidance is traceable back to one overarching instruction. This thesis explains the training system device guidance structure for each organization for certification or qualification, as well as provides recommendations to NAWCTSD to improve its own guidance.

Through analysis of all the existing training system device certification and qualification processes, this thesis provides recommendations to include the necessary stakeholders in the requirements generation phase and throughout the acquisition program, to include a certification or qualification process as part of the acquisition

program, and to test the training system device for the ability to meet the original learning objectives for Training and Readiness (T&R).

Further areas of study are required to include unpublished internal guidance from each organization. There is a possibility that additional guidance exists for training system certification or qualification but is not available to other organizations. Other potential areas of research would include providing a cost-benefit analysis for offsetting aircraft training with aviation training devices.

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I. INTRODUCTION

A. BACKGROUND

Within Naval Air Systems Command (NAVAIR), the Naval Air Warfare Center Training Systems Division (NAWCTSD) is the Navy's source for a full range of innovative products and services that provide complete training solutions. This includes requirements analysis, design, development and full life cycle support. The demands evolving from changes to modern combat, new roles for military operations, and the use of high technology weapons systems place increased emphasis on effective and efficient training solutions.

Aircraft simulator training flight hours have increased in recent years due to rising fuel costs. Training systems are becoming a more attractive alternative as a lower cost training option to provide Training and Readiness (T&R). As a result, greater emphasis will be required to ensure that new and existing training systems are providing the proper skills and attributes for the training mission and is not degrading the training skills. To ensure the training system is providing the necessary potential for T&R credit, a certification and qualification process must be developed. This thesis will evaluate existing training device certification and qualification processes for aviation and examine the requirements from the different agencies that generated their certification and qualification process. Based on the results of this analysis, the thesis will provide recommendations to NAWCTSD for certification or qualification of their aviation training system devices.

B. PURPOSE

The purpose of this thesis is to analyze existing training system devices certification that exists for other organizations and determine why they developed the process. This analysis will be used to provide recommendations to NAWCTSD for its qualification and certification process.

C. RESEARCH QUESTIONS

- What were the stakeholder's requirements for the training systems? How are the requirements specified, and how are they subsequently used in the development process?
- What organizations currently have a training system certification and qualification process? Are there any well accepted “best practices” in the industry?
- Why did the organization develop a certification and qualification process?
- What is the benefit to developing a certification and qualification process? Can it be quantified?
- What is an acceptable reporting process for the certification process?
- What are the tradeoffs for not completing all of the recommended test events for certification? What is the true “return on investment” made in certification and qualification process?

D. BENEFITS OF STUDY

This thesis will provide NAWCTSD a recommendation for Naval Aviation training system device certification and qualification. This may result in cost reductions because fewer aircraft flight hours are used for training.

E. SCOPE

This thesis focuses on providing a recommendation to NAWCTSD by analyzing existing processes for training system devices. The analysis will be dependent on existing documentation.

F. METHODOLOGY

- Conducted literature review of training systems documentation for training system qualifications, certifications, requirements, procedures, instructions.
- Analyzed regulations, policy, procedures, and guidance to determine shortcomings.
- Developed recommendations for improving or writing guidance for NAWCTSD training system certification and qualification process.

II. TRAINING DEVICE CERTIFICATION AND QUALIFICATION PROCESS

A. INTRODUCTION

In order to provide a recommendation for training system certification and qualification, it is important to understand what an aviation training system device is and what is certification or qualification. This chapter will examine:

- What is an aviation training system device?
- When does certification and qualification occur within the systems engineering process?
- What is the purpose of certification or qualification for an aviation training system device?

There several different types of aviation training systems devices as well as different levels of simulation. This chapter will focus on reviewing the different types of aviation training devices and its purpose. After understanding what an aviation training device is designed for, the later chapters will identify the importance of certification or qualification and discuss any shortcomings of the current Federal Aviation Administration (FAA) and military qualification process.

B. AVIATION TRAINING SYSTEM DEVICES

Prior to World War II, the United States was in a vulnerable position having thousands of individuals without a military background who had to be trained quickly to operate sophisticated military equipment. The new military pilots had to be trained in the ways of the military to be molded into combat-ready crews (Jenkinson 1983).

To accomplish this goal, the military created training systems rather than use military equipment and to avoid costly mistakes during training. Military training today is completely different than it was before World War II. Military pilot training consists of classroom training, simulated training events, and flight training events. The classroom training uses a combination of lectures and computer based modules for the student pilot to learn the basics. Flight training devices are available in different configurations.

The most common configuration for the Navy is called an Operational Flight Trainer (OFT). An OFT is a training device that includes the pilot and navigator or weapons officer operating together as one network. A simulator tries to replicate the configuration of the aircraft or the helicopter, and the OFT has the most accurate configuration. This configuration is used to help the pilot, navigator, or weapons officer train to a specific mission the aircraft is designed to deliver. Most OFTs have full motion that replicates the flying motion of the real aircraft. The movement helps provide a realistic environment for the pilots, navigator, and weapons officers as they perform their mission tasks. Figure 1 is what a MH-60 OFT looks like from the exterior. The interior is similar to a MH-60R cockpit.

Figure 1. MH-60R Tactical OFT. (Photograph by Michael C. Barton.)

A Flight Training Device (FTD) is similar to an OFT. A FTD lacks motion but has a full visual system of the exterior environment. A FTD is a full scale replica of an airplane's instruments, equipment, panels, and controls. A FTD can be configured like the airplane's cockpit or it can be an open deck configuration without the small confined area under a canopy. The configuration of the FTD depends on how the instructors plan to use the training device. An open deck area is better for beginners so the instructor can

provide over the shoulder mentoring during training exercises. An enclosed FTD similar to the cockpit is often used for pilots to maintain efficiency. The FTD does not require motion or visual system to meet the criteria outlined by the learning objective. If the learning objective requires motion cueing a different configuration training device would be used such as an OFT. There is no set configuration requirement for an aviation training device to be classified as an FTD (AC 120-45A 1992).

The FTD shown in Figure 2 is for the King Air 350 Pro Line 21 aircraft. The system does not have the motion system like Figure 1 but has the full visual system and cockpit like the aircraft (Wood 2009).

Figure 2. King Air 350 Pro Line 21 FTD. (Photograph by Ron Csuy.)

A Part Task Trainer (PTT) is a training device that does not have a motion base like an OFT or full visual system like a FTD. Most PTTs are used for a specific purpose such as instrument familiarization. The PTT helps a student pilot or Naval Flight Officers (NFOs) become familiar with the cockpit or other missions. This type of training device can be used prior to students entering the OFT or can be a standalone training device. As shown in Figure 3, the example PTT does not have as complex of a visual system as an FTD, or a full motion system as an OFT. The PTT is part of the new P-8A Mission Operator PTT used for individual refresher training (Pierce 2012).

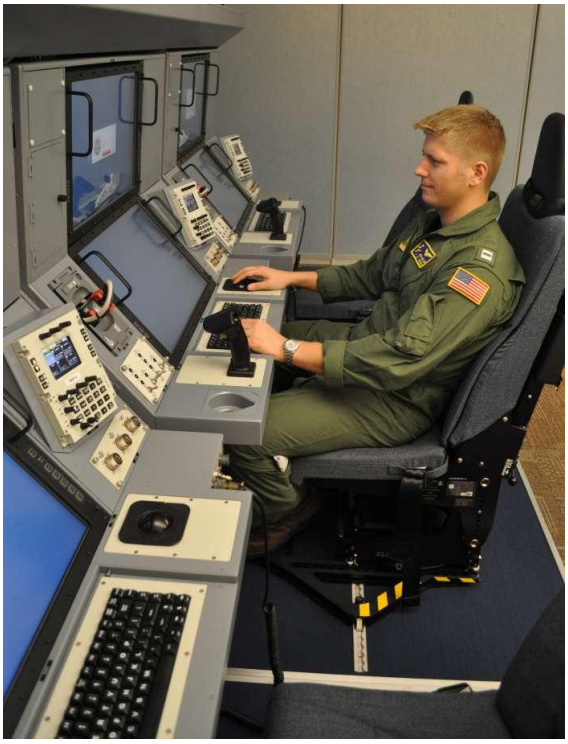

Figure 3. P-8A Mission Operator PTT. (Photograph by Clark Pierce.)

C. THE SYSTEMS ENGINEERING PROCESS

The certification and qualification process is part of the test and evaluation (T&E) phase in the systems engineering process. Systems engineering has been defined in many different ways but the definitions usually have the same goal. The International Council on Systems Engineering (INCOSE) defines of systems engineering as:

> Systems engineering is an interdisciplinary approach and means to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, then proceeding with design synthesis and system validation while considering the complete problem. *(INCOSE 2004, www.incose.org)*

The Department of Defense, Defense Acquisition Guidebook (DAG) defines systems engineering as:

> Systems Engineering (SE) is an interdisciplinary approach encompassing the entire technical effort to evolve and verify an integrated and total life cycle balanced set of system, people, and process solutions that satisfy customer needs. SE is the integrating mechanism across the technical

> efforts related to the development, manufacturing, verification, deployment, operations, support, disposal of, and user training for systems and their life cycle processes; and SE develops technical information to support the program management decision-making process. *(Defense Acquisition Guidebook 2009, 4.1)*

The systems engineering process can be applied to any system that is being designed to accomplish a purpose. For this thesis, the SE process is used for pilot training system design and testing. The T&E phase of the SE process is shown in Figure 4. The T&E process is the right side of the "V" and tests the system at a component level up to the system level, or the entire training system for this thesis. This thesis will focus on the top of the right side of the "V" during the validation phase where qualification and certification takes place at a training systems level just prior to transition to the fleet or customer for use.

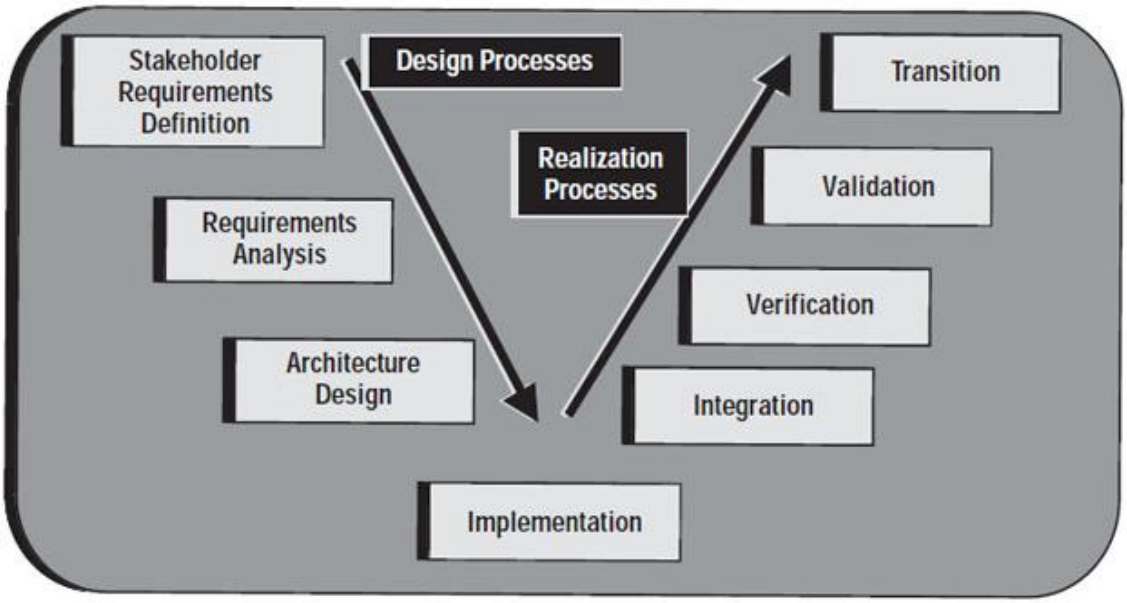

Figure 4. Systems Engineering Process (After Defense Acquisition Guidebook 2009, 4.1)

D. CERTIFICATION AND QUALIFICATION PROCESS

To ensure the training systems are an accurate representative system to use for training, a disciplined approached called certification or qualification must be used to ensure the training device is similar to and closely replicates the aircraft. This method is

used to ensure the student pilot is learning on a system that is close to the aircraft. The training system device must look and fly like the aircraft. If it does not, there is the potential for negative training to occur where the student experiences the aircraft not operating like he or she thought it would, based on having used the training device.

Certification is the last step in the T&E process during the validation phase that ensures the system is working as it was designed to and meets the user's need. "Certification is a formal statement by the architect to the client, or user, that the system, as built, meets the criteria for client acceptance" (Maier and Rechtin 2009, 17).

Thus, as Maier and Rechtin describe in this step, the certification process can be defined as a formal statement to the training system customer that the system, as built, meets the intent of the training system goal. In other words, the training device meets the criteria for training and simulates the aircraft device similar to the operational scenario it is intended to model.

III. TRAINING SYSTEM DEVICE CERTIFICATION AND QUALIFICATION PROCESS REVIEW

A. INTRODUCTION

This chapter will answer the following research questions:

- What organizations currently have a training system certification and qualification process?
- Are there any well accepted "best practices" in the industry?

As indicated in the previous chapter, certification and qualification is the last step in the T&E phase of the SE process prior to delivering the training system to the fleet or end user. The certification or qualification process is the last to ensure the training system device is working correctly and the device is fulfilling the requirements for the user. If this is not followed correctly, the fleet or user will determine if the training system device is working properly or is fulfilling its pilot training need.

This thesis researched several different military, commercial, and federal agencies to develop a list of existing certification and qualification processes. The next sections in this chapter will describe the existing certification and qualification guidance for training systems.

B. FEDERAL AVIATION ADMINISTRATION PROCESS

The FAA regulations that govern aircraft are found in Title 14 of the Code of Federal Regulations (CFR). There are 68 regulations organized into three volumes under Title 14, Aeronautics and Space. The forth volume is for the Department of Transportation (DOT), and the fifth volume is for the National Aeronautics and Space Administration (NASA). Figure 5 is a depiction of how Title 14 is organized. (Aviation Technician Handbook n.d.)

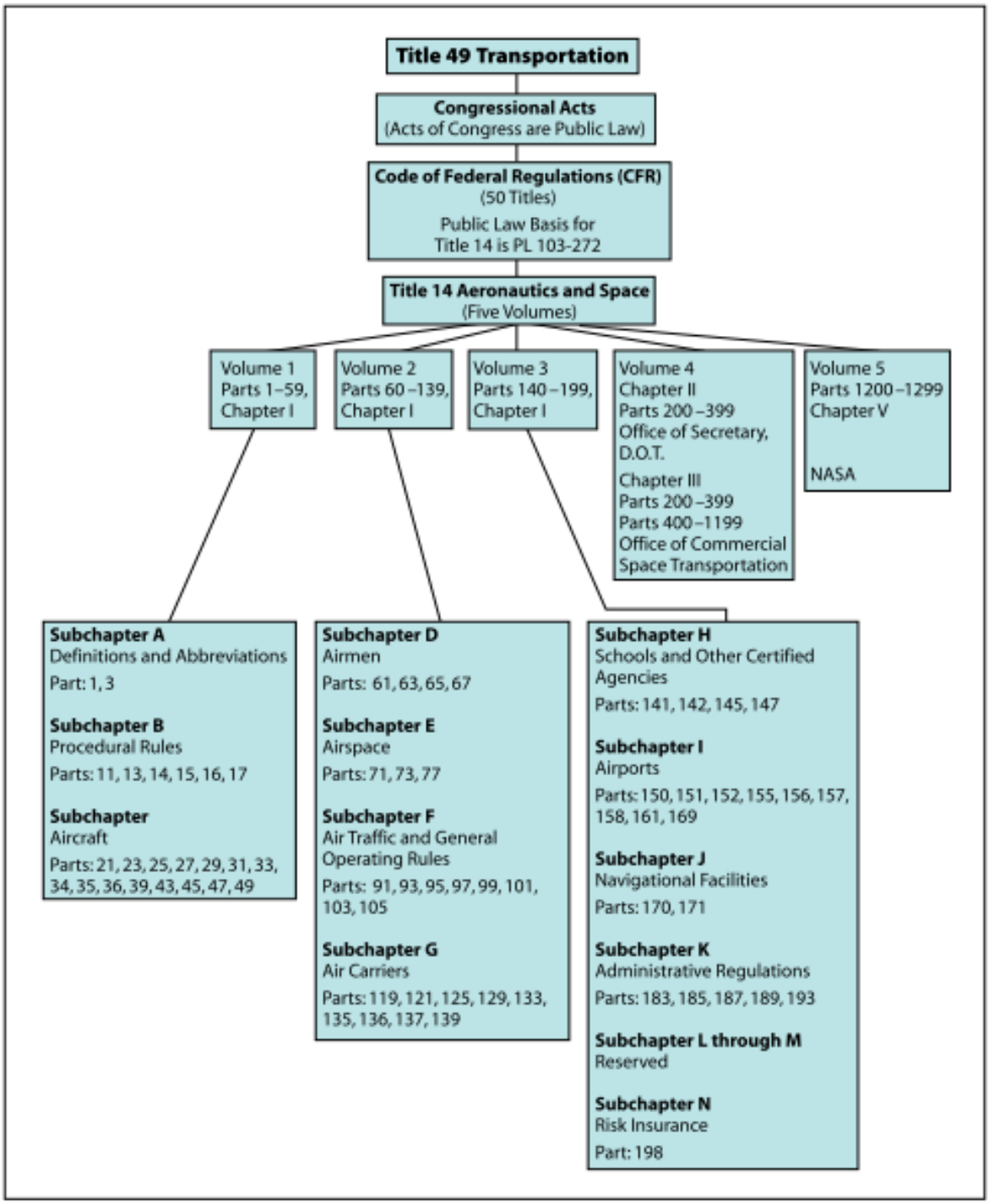

Figure 5. CFR Title 14 Structure (From Aviation Technician Handbook n.d., 12–2)

The FAA rules are referred to as Federal Aviation Regulations (FARs). The FAA FAR is often confused with another set of government regulations called the Federal

Acquisition Regulation, also called FAR, so the FAA regulations are referred to as "Title 14 CFR." (Federal Aviation Administration n.d.) Table 1 lists all the Volumes, Chapters, and Parts for Title 14 CFR. The various parts of Title 14 listed in this table are available electronically on the U.S. Government Printing Office (GPO) website. Part 60 of the CFR, covers the flight simulation training device initial and continuing qualification. (Federal Aviation Administration 2013)

Table 1. Title 14 CFR Parts (From Federal Aviation Administration 2013, www.ecfr.gov)

Title	*Volume*	*Chapter*	*Browse Part*	*Regulatory Entity*
Title 14 Aeronautics and Space	1	I	1-59	Federal Aviation Administration, Department of Transportation
	2		60-109	
	3		110-199	
	4	II	200-399	Office of the Secretary, Department of Transportation (Aviation Proceedings)
		III	400-1199	Commercial Space Transportation, Federal Aviation Administration, Department of Transportation
	5	V	1200-1299	National Aeronautics and Space Administration
		VI	1300-1399	Air Transportation System Stabilization

The FAA has several Advisory Circulars (ACs) that provide additional guidance to assist the aviation community to comply with Title 14 CFR. In the particular, the ACs provides guidance for everything related to complying with Title 14 CFR for aviation. There are four ACs available for the qualification and certification of aircraft simulators used in training programs or for airmen. The four ACs provide guidance to comply with Title 14 CFR, Part 60.

There is an AC for each of the different aircraft simulator types. For example, *Airplane Simulator Qualification*, AC 120–40B, covers all aircraft qualification requirements to comply with Title 14 CFR. Table 2 lists the ACs for all the different aircraft training system devices from fixed wing to rotary wing. (Federal Aviation Administration (FAA) National Simulator Program (NSP) n.d.)

Table 2. FAA ACs for Fixed Wing and Rotary Wing Simulators

Advisory Circular	Subject	Date
120-40B	Airplane Simulator Qualification	7/29/1991
120-45A	Airplane Flight Training Device Qualification	2/5/1992
120-63	Helicopter Simulator Qualification	10/11/1994
121-14C	Aircraft Simulator and Visual System Evaluation and Approval	8/29/1980

C. UNITED STATES AIR FORCE PROCESS

The United States Air Force (USAF) training system device certification and qualification process is outlined in Air Force Instruction 36–2251 (AFI 36–2251), *Management of Air Force Training Systems* (2009). Similar to the FAA, the AFI is traceable back to one overarching regulation, the Department of Defense Directive 5000.01 (DoDD 5000.01) and Department of Defense Instruction 5000.02 (DoDI 5000.02). DoDI 5000.02 provides guidance for engineering, acquisition, and testing for new and modified DoD systems. The DAG provides further clarification of the requirements listed in the DoDI 5000.02 (AFI 36-2251 2009).

AFI 36–2251 provides guidance for managing USAF training systems. "It outlines the requirement to develop, acquire, modify, test, validate, and support training systems, to include but not limited to Aircrew Mission Training Systems, Mission Crew (i.e. Command and Control (C2)) Training Systems, Maintenance Training Systems, Space Training Systems, other Training Systems and Training Services" (AFI 36-2251 2009, 3). AFI 36–2251 is used in conjunction with Air Force Instruction 10–601 (AFI 10–601), *Operational Capability Requirements Development* (2010), Air Force Instruction 99–103 (AFI 99–103), *Capabilities-Based Test and Evaluation* (2009), and Air Force Instruction (AFI 63–101), *Integrated Life Cycle Management* (2013). AFI 36–2251 provides an integrated framework for the implementation of a training system (AFI 36-2251 2009).

This thesis will not analyze the DoDI 5000 series but will review the AFIs related to training systems certification and qualification. USAF has another instruction that also

covers what is referred to as Simulator Certification (SIMCERT) in Air Force Instruction 36–2248 (AFI 36–2248), *Operation and Management of Aircrew Training Devices* (1998). There does not appear to be a connection between AFI 36–2248 and AFI 36–2251. Both instructions cover the same topic of aviation training device certification and qualification but do not refer to either instruction for additional guidance. The scope of AFI 36–2251 is:

> This instruction specifies the responsibilities of the Combat Air Forces (CAF) to operate and manage Training Systems (TSs), including Aircrew Training Devices (ATDs), Training System Support Centers (TSSCs), associated support equipment, courseware, and instruction. The CAF includes the following agencies: Headquarters Air Combat Command (HQ ACC), Headquarters United States Air Forces in Europe (HQ USAFE), Headquarters Pacific Air Forces (HQ PACAF), Air National Guard (ANG), Headquarters Air Force Reserve Command (HQ AFRC), and Headquarters Air Education and Training Command (HQ AETC). *(AFI 36-2248 1998, 4)*

Figure 6 provides a visual depiction of the AFIs and DoDI 5000.02 relationship. This relationship is similar to the FAA Title 14 CFR overarching requirement. Unlike the FAA, the AFIs are not based on the aviation training systems device type. The AFIs are organized to comply with DoDI 5000.02 and Air Force Policy Directive 36–26 (AFPD 36–26) *Total Force Development* (2011) that replaced Air Force Policy Directive 36–22 (AFPD 36–22) *Military Training* (2004). AFI 36–2248 and AFI 36–2251 cover SIMCERT.

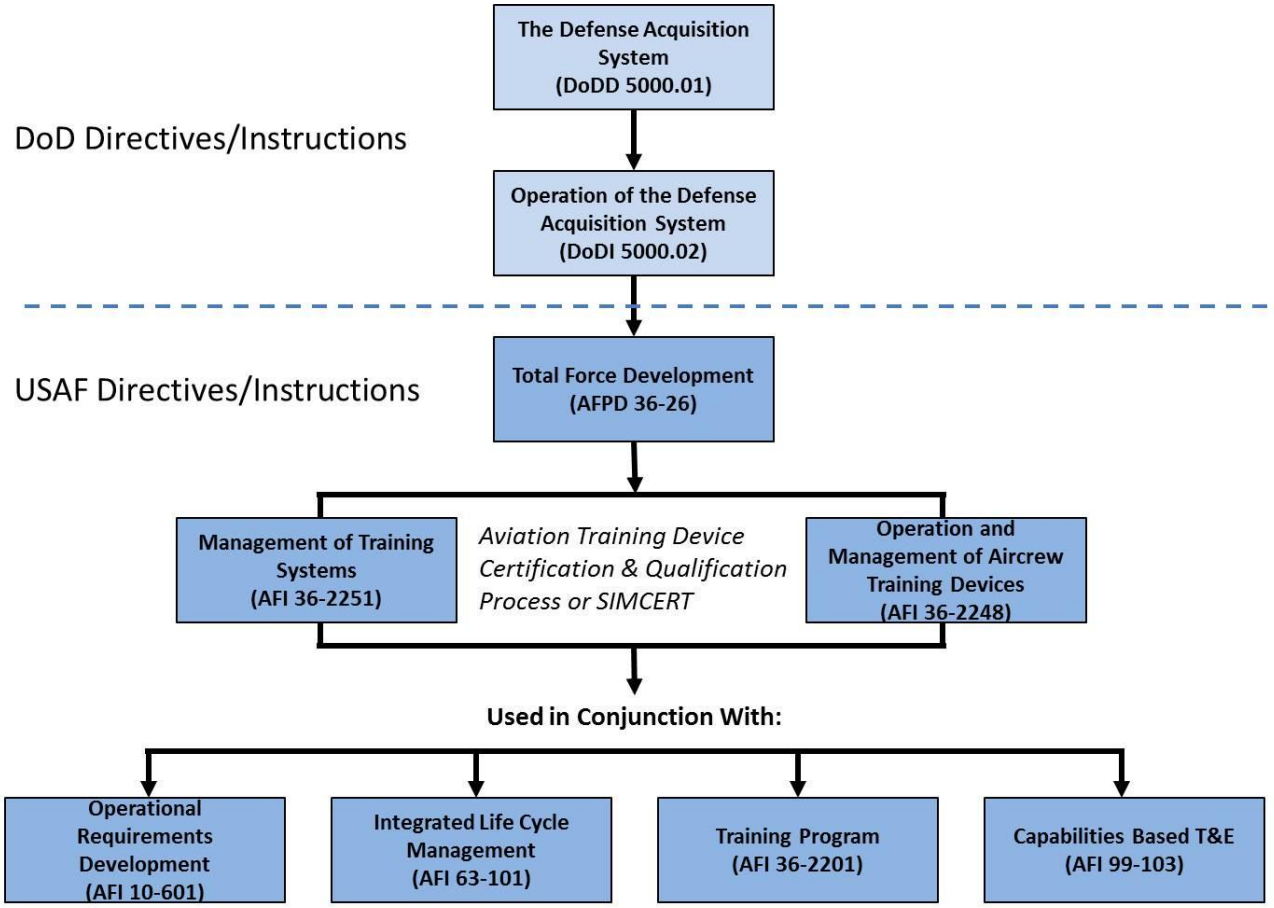

Figure 6. USAF Management of Training Systems AFI Structural Relationship

D. UNITED STATES ARMY PROCESS

The United States Army (USA) has the same requirement as the USAF to follow the DoDD 5000.01 and DoDI 5000.02. After a considerable amount of literature research, it is a safe assumption to conclude that there is no USA specific policy or guidance for training system certification or qualification. It is possible that that the USA is using existing guidance such as the USAF or FAA for aviation training system certification and qualification. Similar to the USAF AFIs, the Army Regulations (ARs) are arranged to comply with the overarching DoDI 5000.02 requirements. Aviation training device management is covered under Army Regulation 350–38 (AR 350–38), *Policies and Management for Training Aids, Devices, Simulators, and Simulations* (2013). (AR 350-38 2013)

AR 350–38 "establishes Army policies and responsibilities for life cycle management of the following areas only as they pertain to training: training aids, devices, simulators, and simulations (TADSS), including tactical engagement simulation (TES), targetry, combat training centers, gaming technologies, range instrumentation, and training-unique ammunition, regardless of training site or event (combat training centers, homestations, institutions, or other training sites or venues)" (AR 350-38 2013, 1). This regulation also expands upon Army Embedded Training (ET) as stated in Army Regulation 350–1 (AR 350–1), *Army Training and Leader Development* (2011). ET is a subset of Army training for systems training. Both AR 350–38 and AR 350–1 are provided to training systems managers as guidance to field training systems to the user quickly and efficiently. However, these regulations do not mention a requirement for training system certification or qualification.

Figure 7 provides a visual depiction of AR 350–38 and DoDI 5000.02 relationship. This relationship is similar to the USAF but AR 350–38 does not provide a certification or qualification process for aviation training devices like AFI 36–2248 and AFI 36–2251 do for USAF aviation training devices.

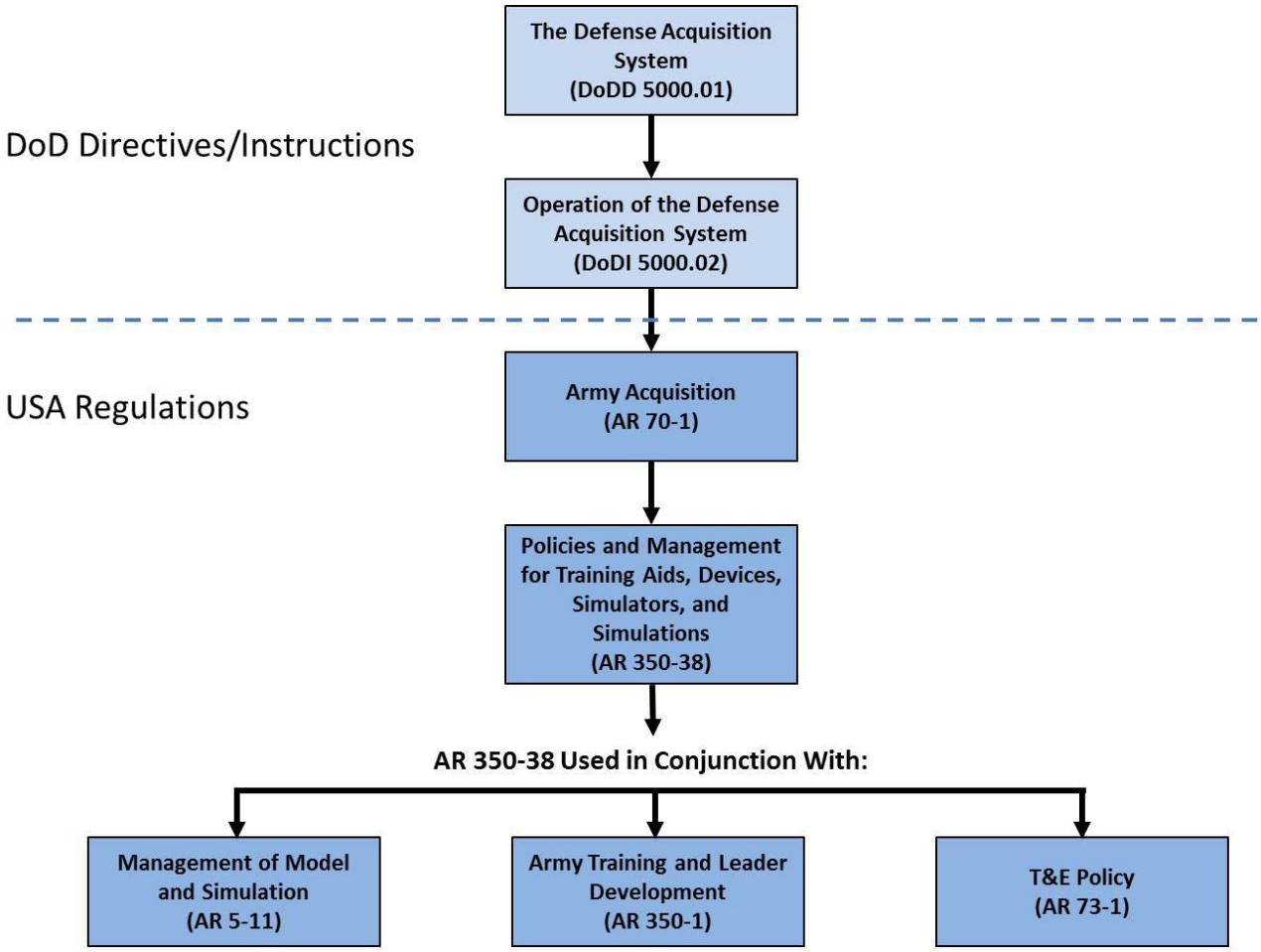

Figure 7. USA Training Device Management AR Structural Relationship

E. UNITED STATES NAVY PROCESS

The USN follows a similar structure to the USAF and USA but does not have a specific instruction for aviation training system management, certification or qualification. The Department of the Navy (DON) does, however, have two different processes called Training Device Certification and Accreditation Process (TDCAP) and Systematic Team Assessment of Readiness (START) (Owen and Meyers 2012).

The START and TDCAP process leverage off of existing DoD, Secretary of the Navy (SECNAV), and NAVAIR instructions to provide certification or qualification for aviation training devices. All the Navy instructions are traced back to the DoDD 5000.01 and DoDI 5000.02. The Navy Instructions are slightly different than the USAF and USA. The Navy has an additional layer of instructions within NAVAIR to provide clarification for DoD, SECNAV, and Chief of Naval Operations (OPNAV) instructions. Figure 8 shows the available instructions and Navy processes for aviation training systems certification or qualification and their relationship to DoDI 5000.02.

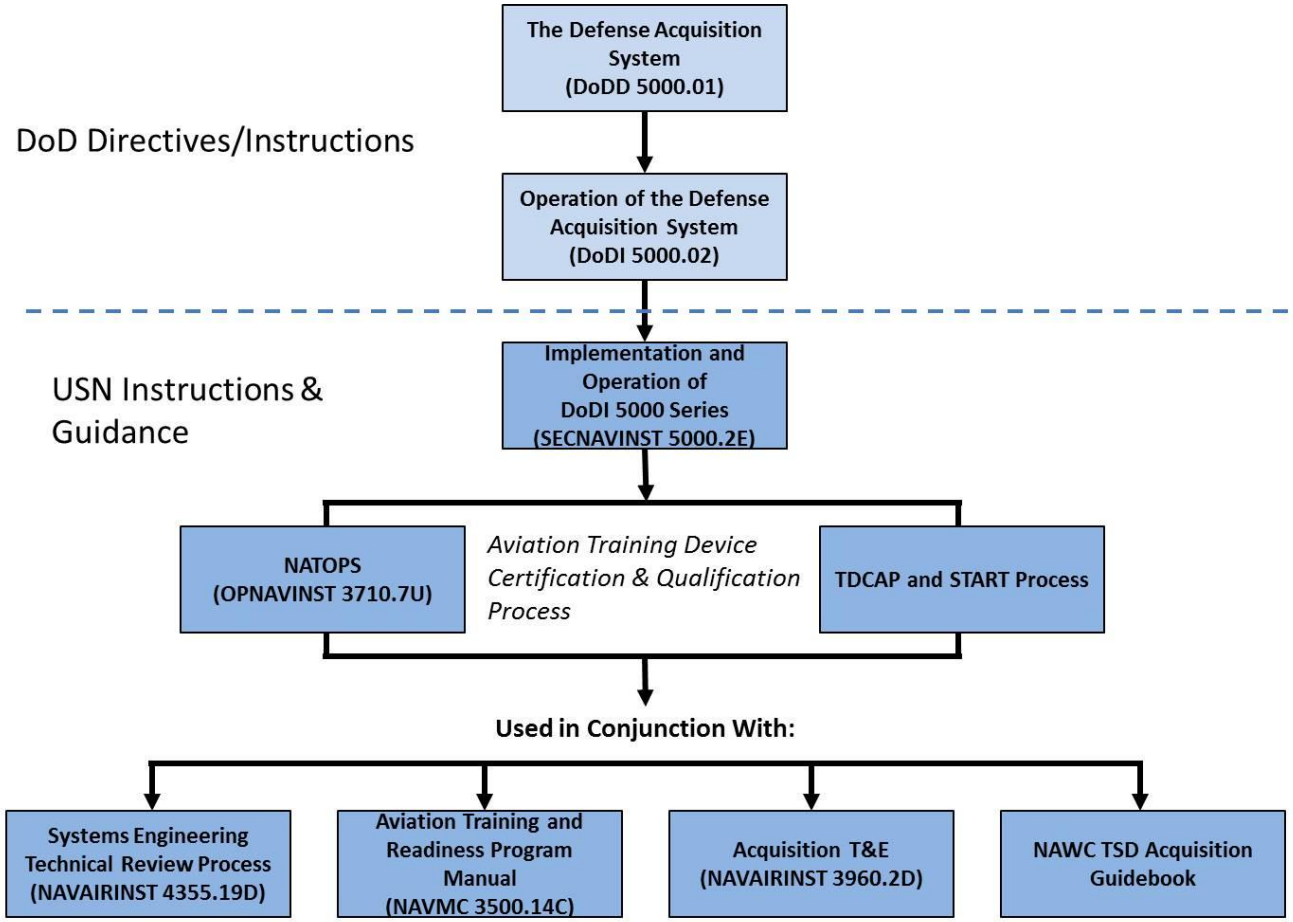

Figure 8. Available USN Training Systems Certification or Qualification Instructions or Guidance

IV. ANALYSIS OF THE EXISTING TRAINING SYSTEM DEVICE CERTIFICATION AND QUALIFICATION GUIDANCE

A. INTRODUCTION

This chapter will answer the remaining research questions:

- What were the stakeholder's requirements for the training systems? How are the requirements specified, and how are they subsequently used in the development process?
- Why did the organization develop a certification and qualification process?
- What is the benefit to developing a certification and qualification process? Can it be quantified?
- What is an acceptable reporting process for the certification process?
- What are the tradeoffs for not completing all of the recommended test events for certification? What is the true "return on investment" made in certification and qualification process?

As seen in the previous chapter, the FAA certification and qualification process flows down from the Title 14 CFR to the corresponding AC that provides guidance for complying with Title 14 CFR. The various ACs are arranged according to aircraft type. For the USAF, USA, and USN, the requirements are based on acquisition regulation and they all flow down from the DoDD 5000.01. The certification and qualification process are included within the USAF, USA, and USN instructions or regulations.

This chapter presents how the existing instructions address the certification and qualification process for aviation training systems. It will provide the USN stakeholder's requirements for aviation training systems certification or qualification to determine whether the existing instructions meet or lack the guidance required for meeting them.

B. STAKEHOLDER REQUIREMENTS

The DON uses a combination of aviation training devices and aircraft to provide T&R. Owen and Meyers provide a good summary of the USN and United States Marine Corps (USMC) stakeholder requirements. "Given the constrained fiscal environment now and in the foreseeable future, the use of aircraft flight hours for training and skill

qualification is a costly solution to maintain. Thus, the use of simulation is becoming an even more attractive alternative to aircraft training flight hours." (Owen and Meyers 2012, 1). As a result, USN and USMC are interested in looking at using more aviation training system devices to provide more T&R credit than the aircraft. The cost to use a training device is less expensive than using an aircraft for training. The price of jet fuel is 3.5 times higher in 2012 than it was in 2000 (Airlines for America 2013). A training lesson that takes two hours in an aircraft costs on average $3,500. This does not include maintenance cost. Maintenance cost would be an additional cost. The operating cost for an aircraft simulator is significantly cheaper since it only uses electricity. The same training lesson in an aircraft simulator would cost under $100. This does not include maintenance cost.

A certification or qualification process is required to show evidence to the user that the training system device can be used for T&R. The existing USN and USMC acquisition and SE process does not cover certification or qualification for new aviation training system devices to determine if the new systems are meeting T&R requirements. The current acquisition process focuses more on Statement of Work (SOW) and performance specification requirements to determine if the training system device was built according to the contract and that it was built correctly. A certification or qualification of T&R report must be presented to the end user to document the capability of the new training device. The certification or qualification report must show the supporting evidence for meeting T&R. This process determines if the training device is the right system for providing T&R, not just for ensuring that the acquisition contractual requirements have been met (Owen and Meyers 2012).

The USN and USMC training systems require an engineering process to ensure the system is designed and tested properly. This provides evidence that the training system meets the original learning objectives listed in the T&R matrix for that skill set. The first step in any new system design is to identify the stakeholders. For the purposes of this thesis, the stakeholder requirement will be limited to the USN and USMC. The goal of the aviation training system is to ensure that the learning objectives can be accomplished with the new aviation training device. This will serve as the primary goal

of the training system. The form should follow the function for the training system and ultimately be certified or qualified back to the original learning objectives (Owen and Meyers 2012). This method is not any different from designing a system in the classical "form-follows-function" systems engineering concept (Maier and Rechtin 2009, 10). Owen and Meyers show the common stakeholders for USN and USMC aviation training system devices.

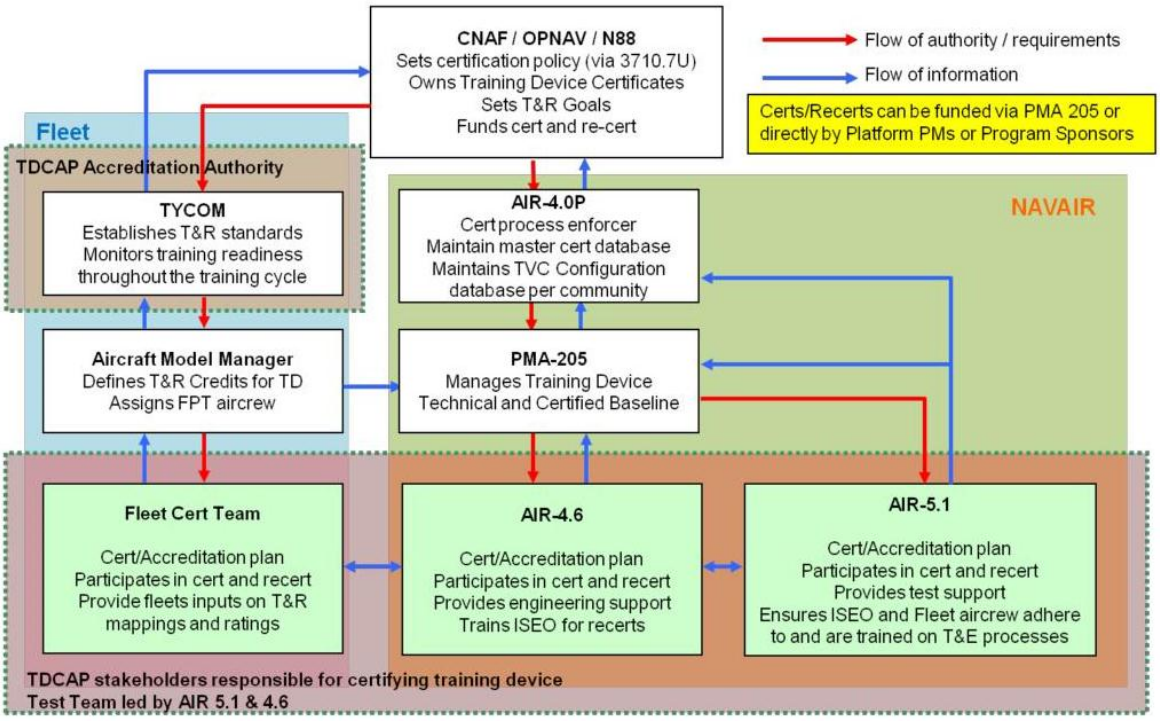

Figure 9. Stakeholders for USN and USMC Aviation Training System Devices. (From Owen and Meyers 2012, 3)

Section C will analyze the existing USN guidance and identify where the current guidance lack the necessary details to fulfill the USN stakeholder's requirements. Finally, it will analyze existing FAA, USAF, and USA instructions and regulations to determine if the guidance meets the USN certification requirements.

C. REVIEW OF EXISTING USN AVIATION TRAINING SYSTEM DEVICE GUIDANCE

The NAWCTSD acquisition programs follow the requirements in the DoDI 5000.02 and NAVAIRINST 4355.19D for systems engineering. NAVAIRINST 4355.19D requires that each training system acquisition program follow the Systems Engineering Technical Review (SETR) process. Each system must go through a Systems Requirement Review I (SRR-I) to determine if the government has the correct requirements to meet the goals for that system. NAWCTSD reviews the requirements to ensure they are capable of meeting the learning objectives for T&R during an SRR-I.

1. Acquisition Guidance and Instructions

Aviation training system acquisitions verify requirements using the DoDI 5000.02 process. The training system acquisition team uses the Front End Analysis (FEA) and training system Concept of Operations (CONOPS) to develop the performance or system specification according the Systems Engineering Plan (SEP) and Military Specification Standard 961E (MIL-STD-961E). This process requires the training system acquisition team to create a Requirements Tractability Verification Matrix (RTVM). The existing DoD, SECNAV, and NAVAIR instructions allow the test team to verify that the training system is built correctly. Often, the training system is not tested in a way to determine if the system is meeting the original training systems goal or learning objectives.

2. START Process

The FEA and CONOPS for training systems are not available, or exist in a draft state, when the systems engineering process starts for new aviation training systems. Often, the original requirements for the aviation training system change during the development process which impact the training system's ability to meet the new learning objectives. The START process was developed to correct the current issues with the current acquisition, systems engineering, and test process. All of the learning objectives are mapped to other learning objectives and T&R events. Owen and Meyers list the six steps in the START process:

1. Tasks are decomposed to their lowest level

2. Tasks are mapped to skills by criticality
3. Tasks are mapped to simulator attributes by criticality and simulator capability
4. A gap analysis is conducted on required simulator attributes and a baseline is set
5. Enhancements and impact on capabilities are identified
6. A cost benefit analysis on candidate upgrades is conducted (Owen and Meyers 2012, 3)

This process assesses existing simulators to determine if the aviation training device meets the learning objectives and T&R. The START process does not incorporate the required feedback in the design process or provide guidance for certification or qualification for aviation training devices.

3. Naval Air Training and Operating Procedures Standardization Instruction

Naval Air Training and Operating Procedures Standardization (NATOPS) instruction is OPNAVINST 3710.7U. OPNAVINST 3710.7U provides guidance for certifying naval pilots, NFOs, and aircrew training for logging flight time. Aviation training devices can be used as an acceptable method to certify flight time for naval pilots if they are listed in Appendix K of that instruction. The instruction does not describe the process to add or remove aviation training devices. The instruction only mentions that "change recommendations to approved simulators may be made by letter to Commander, Naval Air Forces N455 (COMNAVAIRFOR 455)." (OPNAVINST 3710.7U 2009, K-1)

According to Owen and Meyers, the lack of detail in Appendix K of OPNAVINST 3710.7U provides the potential for misinterpretation and inconsistency to the method of adding an aviation training system device to the list for logging training flight time (Owen and Meyers 2012).

4. T&E Instructions

Currently, the aviation training systems follow DoD, SECNAV, and NAVAIR instructions. The DoDI 5000.02 uses the system engineering "V" model for design and verification. SECNAV 5000.2E and NAVAIRINST 3960.2D provide guidance for naval acquisition systems to comply with this method. The existing T&E instructions do not

specifically address training systems certification or qualification process for the final stage of the T&E phase, also described as the top right portion of the systems engineering "V" model. The guidance given in the instructions requires the T&E strategy to test the device to ensure it meets the original system requirements or goal. The guidance does not provide the necessary details to confirm that the training device meets the original learning objectives or is capable of meeting T&R credit. The guidance provides the foundation for the certification or qualification if the certification process is defined as a requirement early in the acquisition program. It is easily overlooked if the design team is not experienced enough to understand that it was overlooked and not identified as a stakeholder requirement. The system engineering and T&E process would be required to derive a certification or qualification process to meet the learning objective and T&R requirement. All of these instructions lack specific system details so that they can be applied to any naval acquisition system.

5. T&R Instructions and Guidance

The USN uses *Training Data Products Military Performance Specification* 29612B (MIL-PRF-29612B) and *Military Handbook* 29612–2A (MIL-HDBK-26912–2A) as a guide for the Instructional Systems Development (ISD) group at NAWCTSD to develop instructional materials for aviation training system devices. MIL-HDBK-26912–2A does not provide details about certification or qualification, but it does say the system must be evaluated. "Evaluation is a continuous process that starts during the analysis phase and continues throughout the development and life cycle of the instructional system. Feedback from the evaluation process is used to modify the training program as necessary" (MIL-HDBK-29612-2A 2001, 8). Feedback is required for fielded training systems from both internal and external users. Periodic evaluations are critical to ensure the training system meets the original training goal. The users might be spending more time than required to complete the necessary training. The evaluation may suggest a modification to correct this problem. MIL-HDBK-29612–2A suggests using FAA training system device certification or qualification when required but does not direct the developing agency or engineering team to use it exclusively (MIL-HDBK-29612-2A 2001). Similar to OPNAVINST 3710.7U, this handbook does not provide enough detail

to evaluate the aviation training device. The handbook is designed to cover all learning objectives and T&R for all the different types of instructional systems, not just aviation training devices.

The USMC uses Navy Marine Corps 3500.14C (NAVMC 3500.14C) *Aviation Training and Readiness Program Manual* (2011), as a reference to develop T&R for USMC aviation programs. NAVMC 3500.14C requires a committee to complete a Training Device Event Essential Subsystem Matrix (EESM) for each aviation community that is using a training device for T&R credit. Table 3 is an example subsystem list required to take T&R event credit in the aviation training device (NAVMC 3500.14C 2011).

Table 3. Example Subsystems Required for T&R Credit (After NAVMC 3500.14C 2011, 6–38)

Aerodynamic Model
After Action Review (Debrief Station/ Debrief Playback, etc)
Aircraft Survivability Equipment
Aural
Automatic Flight Control System
Caution Warning System
Cockpit Displays
Cockpit Instruments
Cockpit Panels
Comms/ICS
Copilot/Aircrew Systems (as applicable)
Flight Controls
Instructor Operator Station
Landing Gear System (as applicable)
Lighting System
Mechanical Diagnostic System
Miscellaneous Mission Systems
Miscellaneous Switches/knobs (blade fold, anti-ice)
Mission Planning Interface
Motion Systems
Moving Models (Ships, Aircraft, Vehicles, and associated capabilities/signatures)
Navigation systems
Operational Flight Program/SCS (current flight software)
Sensor Systems
TEN/Networking Capability
Visual System (Environmental Conditions, Database Coverage, etc.)
Visual System
Weapons Systems

NAVMC 3500.14C lists example subsystems to take T&R event credit but it does not describe how these forms or devices meet the functional requirements for T&R event credit. The instruction does not provide the proper guidance to perform a proper system decomposition to map the various subsystems or form to the T&R event credit of functional requirement. This instruction lacks the guidance to perform this task to ensure the aviation training system device will be designed correctly to meet the T&R event or learning objective requirements.

6. TDCAP

TDCAP is a task-based/attribute evaluation to determine if the training system has the ability to provide the required training by examining the available sensory inputs or attributes. Example attributes examined during the TDCAP process are visual, audio, touch cues, and motion. Each attribute is analyzed against its required task such as execute ground taxi, perform air intercept, and landings for example. The design and test team need to understand what attributes are required to provide proper training.

> TDCAP defines the training device's attributes required to support the design, development, and test of the training solution to meet the tasks associated with the platform's T&R events and LOs. Using both quantitative and qualitative measures, TDCAP can evaluate the fidelity of the training device against the platform's hardware and software configurations including flying qualities, air vehicle systems, mission environments, weapon systems capabilities, and distributed training to validate the capabilities of the training device to successfully meet the T&R requirements of the modeled system. *(Owen and Meyers 2012, 4)*

As Owen and Meyers describe, TDCAP is a well-documented process that meets all the DoD, SECNAV, and NAVAIR acquisition instruction requirements discussed earlier in this chapter. TDCAP's primary goal is to minimize an acquisition program's cost and schedule. This process also provides additional guidance to ensure the requirement generation and validation processes provide an objective assessment to determine if the aviation training system device is capable of meeting T&R events or learning objectives (Owen and Meyers 2012).

TDCAP is a combination of MIL-HDBK-29612–2A and the START process. The START process was developed to examine existing training devices to provide an assessment to see if the training device was acceptable for taking T&R event credit. As a result, the START process provides evidence that the training device is capable of meeting T&R event credit, or the process identifies certain attributes that require improvement to enable the device to be capable of being used to take T&R event credit (e.g., visual or audio cues). The ability to identify areas of possible improvement make it possible to more effectively train aviation personnel and provide a less costly alternative to taking T&R event credit in an aircraft versus using an aviation training device. This

potential savings could provide a favorable return on investment for training (Owen and Meyers 2012). The cost savings by using an aviation training system device instead of an aircraft could easily be developed with cost data. This thesis does not quantify the potential cost savings but recommends further research on the cost for taking a T&R event credit in an aircraft versus an aviation training system device.

The final product of TDCAP is a results report. The report summarizes the aviation training device's capability to meet the necessary learning objectives, T&R events, and training tasks associated with the training goal. Ultimately, the report could be available to the decision-makers to determine if the aviation training device should be added to the list of approved aviation training devices in Appendix K of OPNAVINST 3710.7U. The following description is provided by Owen and Meyers for the TDCAP report:

> This results report represents the TDCAP testing evidence and is meant to inform the user community's accreditation decisions, and should not be taken to imply that any user community shall follow the recommendations of the report. The triggers that can initiate the TDCAP are defined as followed:
>
> 1. Initial validation of a training system. Initial delivery of a training device will require TDCAP to baseline the device's ability to produce authentic trainee task performance to meet the training task/T&R identified for the platform's configuration.
>
> 2. Changes to training system configuration. Changes to the hardware or software configuration of the training device may require re-certification of associated training capabilities.
>
> 3. Changes to platform's configuration. Changes to the hardware or software configuration of the operational system that has been modeled may require re-certification of the training device to ensure new capabilities and events can be taught with the device.
>
> 4. Task/Mission update. The TDCAP process validates the training device's ability to support training for changes to platform tasks/mission sets.

5. Life cycle periodic re-certification. Since the training device's performance may degrade over time, the PM or user community has the authority to establish a periodic re-certification plan to ensure the device's continued compliance with training requirements.

6. As requested. Other circumstances may require additional TDCAP activities and a TDCAP analysis may be conducted at the request of an appropriate stakeholder or stakeholders. *(Owen and Meyers 2012, 5)*

The scenario provided above is for an existing or final phase in T&E for new aviation training devices similar to the START process. TDCAP can be applied during the acquisition process unlike the START process. "The acquisition support portion of TDCAP is divided into four primary sections: 1) Planning/Preparation; 2) Requirements Generation (Steps through SRR I); 3) System Design and Development (Steps to CDR); and 4) Training Device T&E" (Owen and Meyers 2012). Figure 10 and Figure 11 show the iterative process within the SETR process leading up to SRR-I, and after SRR-I, to delivery.

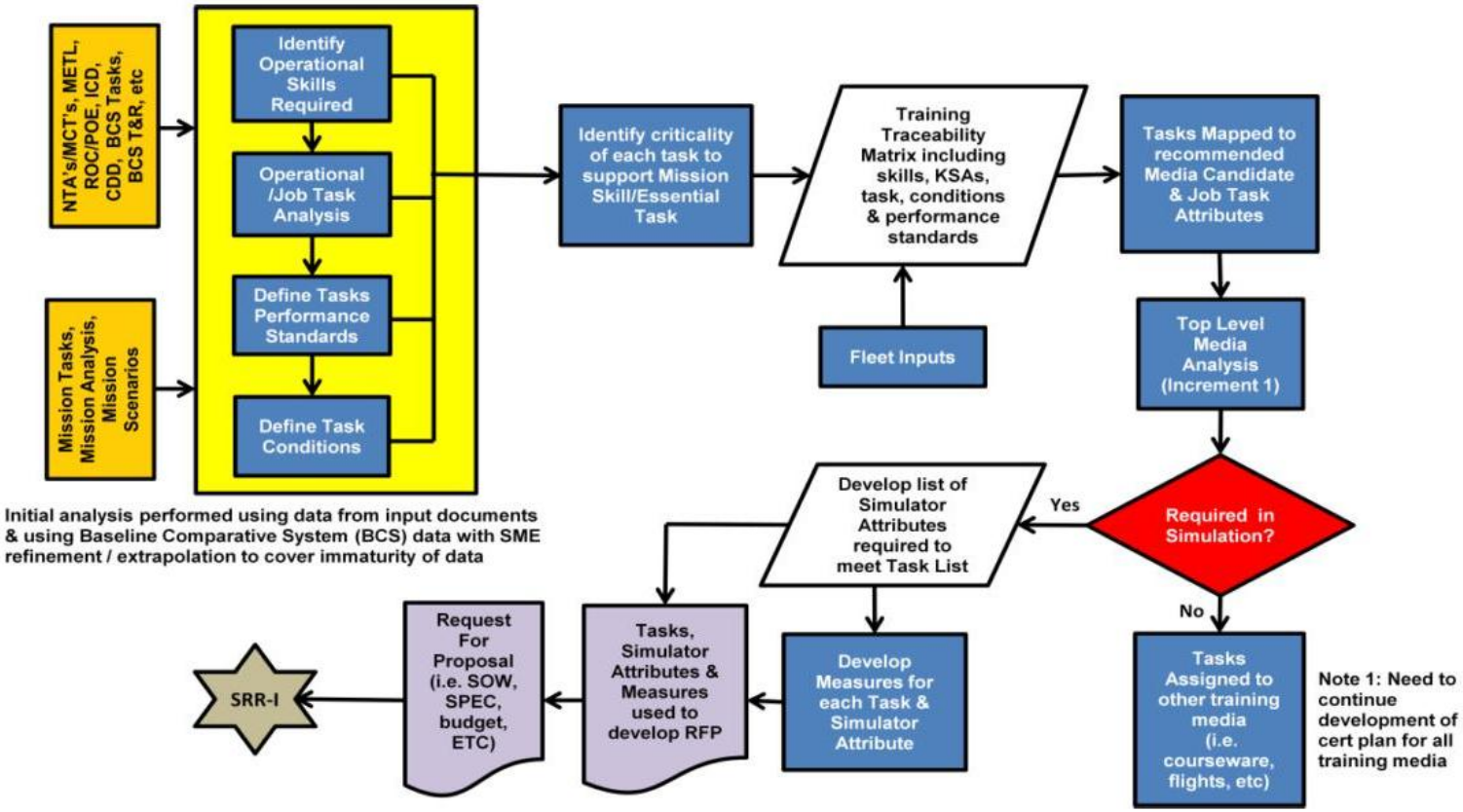

Figure 10. TDCAP Pre SRR-I. (From Owen and Meyers 2012, 6)

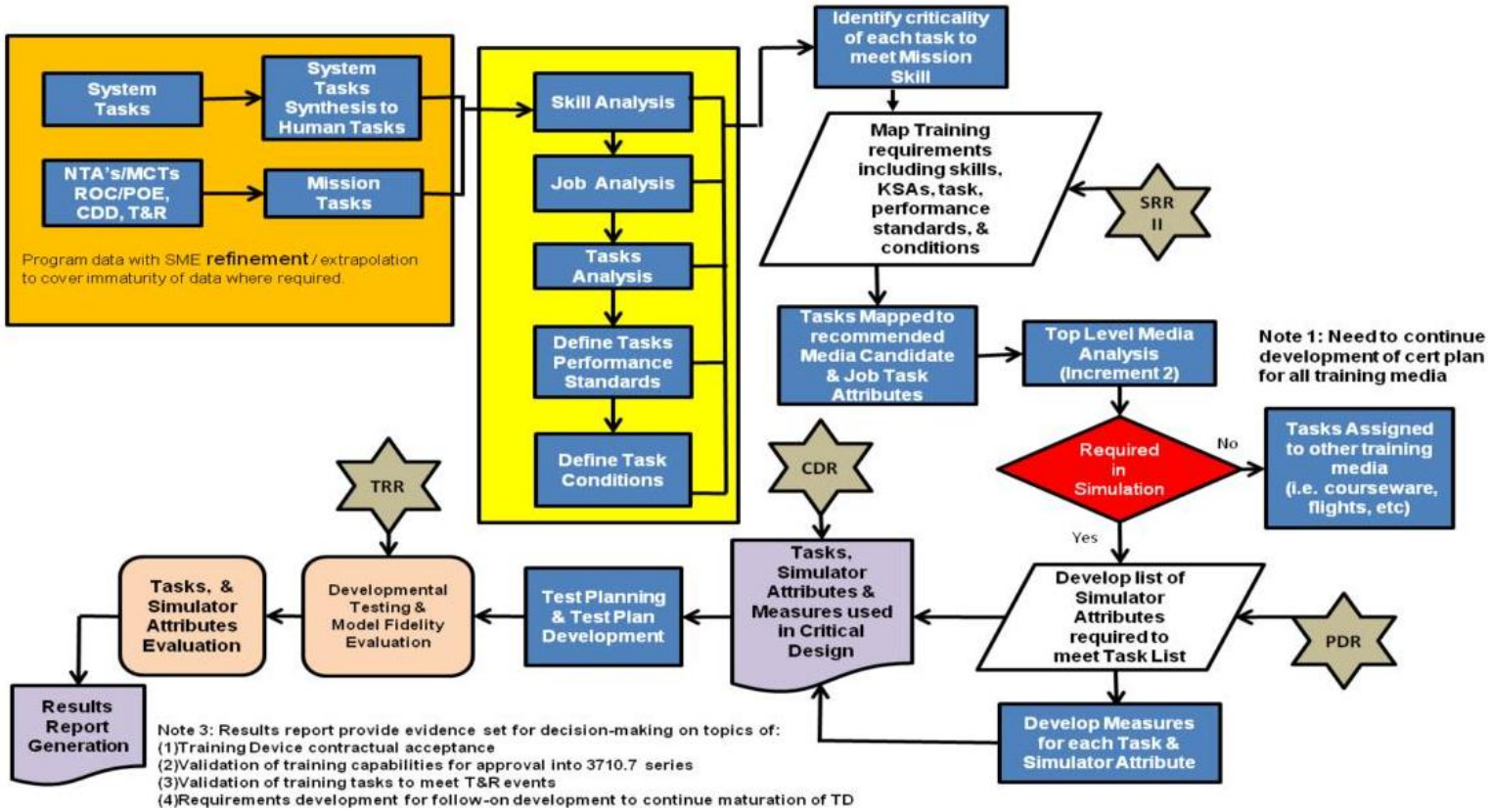

Figure 11. TDCAP Post SRR-I. (From Owen and Meyers 2012, 6)

7. Summary

There is an overwhelming amount of information available about aviation training systems management, acquisition, design, engineering, and testing. The USN has a lot of instructions and guidance currently available to create a certification or qualification plan for new or existing aviation training system devices. The TDCAP and START processes are achieving the same goal by analyzing existing aviation training system devices to determine what learning objectives or T&R events can be met. The two processes also quantify the capability of the aviation training device to meet the learning objectives or T&R events. However, START and TDCAP follow many of the same methods described in DoDI 5000.02, SECNAVINST 5000.2E, NAVAIRINST 4355.19D, and NAVAIRINST 3960.2D. TDCAP does not show the trace back to the original DoDI 5000.02 instruction to ensure the training device team understands the reasoning behind the process. TDCAP is structured and organized similar to a functional decomposition for a system. In this particular process, the goal is to teach "learning objectives," the functions are the different "tasks," and the forms are the "attributes." As long as the USN training system team can understand this relationship, they can discuss the training system device design solution with stakeholders, SETR chairs, and program managers who might not have experience or knowledge with aviation training terminology.

D. REVIEW OF EXISTING FAA AVIATION TRAINING SYSTEM DEVICE GUIDANCE

As discussed in Chapter III, the FAA regulation is referred to as the "Title 14 CFR" and is the overall requirement for qualifying aviation training devices that can be used for pilot training. The ACs are provided by the FAA for additional guidance to comply with the Title 14 CFR requirements. This section will analyze ACs listed in Table 2.

1. Airplane and Helicopter ACs

The FAA developed a certification and qualification process for the training system to match the capabilities of the aircraft it was simulating. "As technology

progressed and the capabilities of flight simulation were recognized, FAR revisions were made to permit the increased use of simulators in approved training programs" (AC 120-40B 1991, 3). The ACs were created to ensure the aviation training system met the requirements for training. Simulators have been used in the commercial aviation industry since the 1950s. As such, the FARs have been slowly revised over time to ensure the new aviation training devices meet the original training system goals to match the aircraft for training. The most significant change to the FAR was made in the 1970s as technology improved to include FAR Amendments 61–62 and 121–108 permitted additional use of visual simulators in December 1973. "Amendments to FAR Section 121.439 permitted simulators approved for 'the landing maneuver' to be substituted for the airplane in a pilot recency of experience qualification" (AC 120-40B 1991, 3). All of these changes to the FAR provided a significant step towards the development of Amendments 61–69 and 121–161 issued June 24, 1980, which contained the FAA Advanced Simulation Plan. This trend showed an increased use and demand for quality simulation by the commercial aviation industry.

The need to create an aviation training device certification and qualification process was required after the FAA allowed training system devices to be used to log flight training time. Each FAA aviation training device AC is organized according to aircraft type. All the ACs listed in Table 2 follow the same trend. The FAA aviation training device is compared to the aircraft cockpit depending on the aircraft type. In addition, the FAA has different levels of qualification depending on the level the aviation training device is constructed to represent. For example, an OFT has the capability of using motion and full visual displays in the training device. This aviation training device would be certified to the highest level of qualification of representing the aircraft during training scenarios. The FAA does not believe the highest level is required for all aviation training devices. The FAA Advanced Simulator Plan describes the different phases as Phase I, Phase II, and Phase III. The training credits for nonvisual training devices used to be delineated in FAR Part 61, Appendix A, and FAR Part 121, Appendices E and F in the past. Credits for Phase I, Phase II, and Phase III were contained in the Advanced Simulator Plan. The four different levels of simulation were Basic (nonvisual and visual

simulators), Phase I, Phase II, and Phase III. “Each of the four levels is progressively more complex than the preceding level and each contains all the features of preceding levels plus the requirements for the designated level” (AC 120-40B 1991, 3). FAA training system or simulator qualification guidance advanced as simulator capabilities advanced. The FAA continuously reviews the existing qualification criteria for simulators with both government and industry resources. This ongoing effort requires active participation by all the stakeholders.

The FAA and industry reviewed the wide spectrum of aviation training system devices or simulators and documented the required standards and permitted uses for training credits. As a result, the FAA created a new method to classify the different levels of simulation used by aviation training system devices. The phase concept is not used any longer. The old phases were derived from the FAR provision which allowed operators to upgrade their simulator in phases while using the enhanced capability for training. This method made it possible for the training system device to be qualified at a lower phase then be used operationally for training with the higher phase expectations. This old method of qualification would not discover and higher phase requirements since it was never followed to begin with. The new process requires the user to determine the required level of certification required for training. The simulator is then designed, built, and qualified to the required level of FAA simulation. To meet the new process, the FAA developed the different qualification levels that exist today. The phases were renamed as levels according to the simulator capability. The new designations are defined in FAR Part 121 Appendix H, and AC 120–40B. The different FAA qualification levels are:

- Level A – Visual
- Level B – Phase I
- Level C – Phase II
- Level D – Phase III

The FAA uses an Approved Test Guide (ATG) to qualify the simulator to the different Level of A through D. The ATG is a document developed by the FAA as a means to compare an aviation training device to the aircraft in terms of performance. The ATG requires both aircraft and training device data to support the validation. The Master

Approval Test Guide (MATG) is the FAA approved ATG that requires the FAA to witness the test results during the qualification phase of testing. The MATG is used to document the results and configuration for future modifications or enhancements (AC 120-40B 1991).

The National Simulator Evaluation Program created a qualification guideline that is included in AC 120–40B Appendix 1, Simulator Standards. The FAA National Simulator Program Manager (NSPM) can provide a recommendation to the Principle Operator Inspector (POI) or certificate holding office to approve the aviation training device for use within the training program (AC 120-40B 1991).

Table 4 shows one of the example evaluation criteria included in Appendix 1 of AC 120–40B. There are several different evaluation criteria listed in Appendix 1 arranged according to the different system in the aviation training device, such as cockpit, motion system, etc., required.

Table 4. Example Airplane Simulator Qualification Criteria (After AC 120–40B 1991, A1–1)

	Simulator Level				Comments
2. General	A	B	C	D	
a) Cockpit, a full-scale replica of the airplane simulated. Direction of movement of controls and switches identical to that in the airplane. The cockpit, for simulator purposes, consists of all that space forward of a cross-section of the fuselage at the most extreme aft setting of the pilots' seats. Additional required crewmember duty stations and those required bulkheads aft of the pilot seats are also considered part of the cockpit and must replicate the airplane.	X	X	X	X	

Appendix 2 of AC 120–40B covers the validation test process. The validation test process described in Appendix 2 requires the test conductor and NSPM to record each test event in the aviation training device and compare the test data to aircraft source data. During this phase of testing, the FAA requires the entire aviation training device system to be tested. The FAA will not accept the sub-level component test results for data. The

system level test is required according to FAR part 121, Appendix H, for Level D qualification. The ATG for validation testing must include all the details of the test, such as instrumentation tolerances, instrument calibrations, and aircraft data tolerances. Appendix 2 contains the Table of Validation Tests that is required to be completed. Table 5 shows an example validation test point to generate qualification data. Similar to Appendix 1, Qualification Criteria, Appendix 2 contains several pages of validation test scenarios (AC 120-40B 1991).

Table 5. Example Airplane Validation Test (After AC 120–40B 1991, A2–3)

Test	Tolerance	Flight Condition	I = Initial Evaluation R = Recurrent Evaluation ication Requir				Comments
1. Performance			A	B	C	D	
b) TAKEOFF			X	X	X	X	
Ground Acceleration Time and Distance	+/- 5% Time and Distance or +/- 5% Time and +/- 200 Feet (61 Meters) of Distance	Ground/Takeoff	IR	IR	IR	IR	Unfactored aircraft certification data may be used. Acceleration Time and Distance should be recorded for a minimum of 80% of total segment.

AC 120–40B Appendix 3 covers the functions and subjective test phases for the FAA qualification. This process allows aircraft pilots to evaluate the simulator and compare it to the aircraft. Unlike the previous processes, this allows the pilot to comment on the handling, performance, and training capability without using aircraft/training device performance data. As the title suggests, this process allows subjective comments and might cover design flaws that were missed during the detailed systematic testing covered by Appendix 1 and 2. Appendix 3 has a table that is several pages long similar to Appendix 1 and 2 but the pilot enters information in the comments section about handling, appearance, etc. The table in Appendix 3 needs to be completed during the function and subjective evaluation. After completing all the testing from Appendices 1, 2, and 3, the application letter in Appendix 4 must be completed to request certification for the specific level the simulator was designed for, Level A, B, C, or D. The application letter quotes the specific requirements listed in the Title 14 CFR. Appendix 5 is the last appendix in AC 120–40B. It applies to aircraft training devices that will be used to train

pilots for windshear. This appendix is required for the training devices that are required to comply with FAR Part 121 (AC 120-40B 1991).

2. Summary

FAA *Helicopter Simulator Qualification*, Aircraft Circular 120–63 (AC 120–63) is formatted in exactly the same way as AC 120–40B. The only difference is that AC 120–63 is tailored to helicopters or rotary wing aviation training devices. AC 120–63 has five appendixes like AC 120–40B but has helicopter features (AC 120-63 1994).

After a thorough literature analysis, it is safe to conclude that the FAA ACs only cover aviation training device qualification or certification. The FAA does not appear to cover what training device configuration is the most cost effective or the best configuration to use for training. Instead, the FAA has a very thorough process to certify or qualify the aviation training device is exactly like the aircraft it is used to simulate. This approach assumes the upfront requirements generation within systems engineering was performed to ensure the method of training is the proper method to meet the stakeholder's requirements. The conservative approach is to use the highest level of certification; Level D for example, is the closest configuration with tactile cues to replicate aircraft operation. This approach could lead to a costly acquisition when perhaps the FTD would have been sufficient. The approach provided in the ACs is an excellent approach for certification or qualification when the proper aviation training functions that lead to forms are determined. This will determine the proper type of aviation training device, FTD, OFT, etc.

E. REVIEW OF EXISTING USAF AVIATION TRAINING SYSTEM DEVICE GUIDANCE

The USAF aviation training system guidance is similar to the DON's. All the USAF aviation training systems follow DoDI 5000.02 and USAF acquisition system guidance for aviation training systems. All the AFIs and AFPDs are traced back to the requirements listed in DoDI 5000.02. AFPD 36–26 is the first layer in USAF policy for acquisition systems that includes aviation training system devices.

1. Acquisition Policy, Guidance, and Instructions

AFPD 36–26 requires all USAF acquisitions to follow the goals for acquisition. The following statement is from AFPD 36–26 describing how the USAF is to manage training systems that includes aviation:

> Establish a learning capability that is agile and robust enough to satisfy mission generated training and mission rehearsal requirements across Services, joint, interagency, intergovernmental, and multinational operations. Training must be capabilities-based and dynamic in responding to the changing strategic environment as well as to opportunities and challenges posed by technological transformation. *(AFPD 36-26 2011, 3)*

This is the AFPD that all of the AFIs are required to comply with for all of the USAF acquisitions including aviation training systems. AFPD does not provide training system specific guidance, but does require training systems to be capabilities based. This instruction is the AFPD that links the AFIs to the DoDI 5000.02 for systems acquisition.

2. Training System Management Instruction

As mentioned in Chapter III, the USAF aviation training systems are managed by AFI 36–2251 and AFI 36–2248. AFI 36–2251 provides the management framework for acquisition, programming, documenting requirements, and testing in accordance with DoDI 5000.02 and AFPD 36–26. The requirements for aviation training system devices are generated using DoDI 5000.02 and USAF 10–601. This process is similar to any other USAF acquisition process. In addition, AFI 36–2251 requires the acquisition team to work with the Air Force Career Field Managers (AFCFMs), Air Education and Training Command (AETC), and Training Pipeline Managers (TPMs) through a formal Utilization and Training Workshop (U&TW) as detailed in AFI 36–2201. All the aviation training devices should be developed when supported by the Instructional System Development (ISD) analysis. Heavy emphasis is given to ensure the ISD analysis includes safety, quality of training, and state of readiness. AFI 36–2251 also covers other types of training devices, but this thesis will only focus on aviation training devices (AFI 36-2251 2009).

AFI 36–2251 continues to describe the agencies responsible for training systems, including the Secretary of the Air Force, Lead Command User Commands (LC/UCs), AETC, Air Force Material Command (AFMC), Air Force Space Command (AFSPC), and Space Training Acquisition Office (STAO). Aviation training system device management roles and responsibilities are covered in Chapter 3 of AFI 36–2251. Chapter 3 describes how all the different organizations will work together to ensure the aviation training system device acquisition or modification includes all of the USAF stakeholders. The process is required to ensure the training system team is translating operational and training requirements into contractual terms and system/technical performance requirements. This process ensures the USAF stakeholders agree during the requirements generation process to ensure the correct capability/training requirement is correctly documented. This avoids an interpretation of the aviation training device requirements during the contract or performance specification creation. The management team works at the appropriate level within USAF or DoD to ensure the requirements are proper for the level of effort. Chapters 4 and 5 continue to describe the acquisition and management structure, required meetings, and oversight for all training systems (AFI 36-2251 2009).

Aviation training system device qualification or certification, or as the USAF refers to as SIMCERT, is covered in Chapter 6. SIMCERT is described as:

> Simulator certification (SIMCERT) ensures that Air Force prime mission system simulators/services and their components support accurate and credible training for allocated tasks, missions, and events including DMO activity, through verification and validation of training system hardware and software performance. *(AFI 36-2251 2009, 13)*

SIMCERT is used in conjunction with Simulator Validation (SIMVAL). SIMVAL verifies and validates the simulated environment used in the aviation training system device is accurately represented. Both SIMCERT and SIMVAL compare the aviation training system to the prime mission that the system is modeling. These processes are used for single aviation training devices and aviation training devices that are joined together for distributed network training. More importantly, SIMCERT and SIMVAL provide the stakeholders an assessment of the capabilities and limitations of the

aviation training system. The results of SIMCERT and SIMVAL provide an audit trail for training effectiveness and quality assurance.

It is up to the Lead Commands (LCs) LCs to determine the frequency for SIMCERT or SIMVAL evaluations after the initial certification or validation. The evaluation frequency is required to be documented in the System Training Plan (STP). In addition to this, the SIMCERT plan is required to be documented in the Master SIMCERT Plan in accordance with Air Force Instruction 10–1001 (AFI 10–1001), *Verification, Validation and Accreditation (VV&A).* All new aviation training devices are required to complete the SIMCERT process within the first 120 days upon delivery of a new training system. The SIMCERT report supports the accreditation of the aviation training system to meet the training goals. SIMVAL is used more for mission training to ensure the scenario is closely represented to the scenario using the SIMVAL report to document the results. AFI 36–2251 does not provide the framework for a SIMCERT or SIMVAL plan. This instruction doesn't provide guidance to construct a SIMCERT or SIMVAL report either. The instruction only requires USAF aviation training devices to develop, execute, and report the SIMCERT and SIMVAL process (AFI 36-2251 2009).

3. Aircrew Training System Management

AFI 36–2248 is the other USAF instruction that covers SIMCERT and SIMVAL for aviation training systems. This instruction covers operating and managing aircrew training devices for Combat Air Forces (CAF). The instruction does not provide any additional guidance, only mirrors the same SIMCERT guidance provided in AFI 36 2251. AFI 36–2248 does not provide any requirement or guidance for SIMVAL (AFI 36-2248 1998).

4. Operational Capability, Life Cycle, Training, and Test Management Instructions

AFI 36–2251 referred to several other AFIs to support aviation training system device management. These instructions are AFI 10–601, AFI 63–101, AFI 36–2201, and AFI 99–103. AFI 10–601 covers instructions to develop operational capability requirements for all USAF systems. This instruction does not refer to any training system device requirements. It only provides additional guidance for USAF acquisition programs

to adhere to the requirements in DoDI 5000.02. AFI 63–101 contains the directive for the overarching processes and procedures required for execution of any USAF program. This AFI covers high level acquisition, engineering, logistics, and disposal or all USAF systems. It does not cover any specific guidance for aviation training systems other than the typical life cycle responsibilities. AFI 36–2201 provides instructions for overall USAF training, classroom, recruitment, etc.. AFI 36–2201 provides more information about the ISD process that was referred to in AFI 36–2251. The following description of ISD was taken from AFI 36–2201:

> The ISD process provides a systematic approach to planning, developing, and implementing training and education. The goal of ISD is to increase the effectiveness and cost efficiency of training by: developing instruction based on job performance requirements; eliminating irrelevant skills and knowledge instruction from courses; and ensuring graduates acquire the necessary knowledge, skills, and abilities to do the job. *(AFI 36-2201 2010, 8)*

The ISD process looks at the overall training process to determine if it is the right training and is effectively training USAF personnel as it was designed. The goals of the ISD process are similar to SIMCERT. The ISD process is applied to all training but SIMCERT is only applied to training system devices. The last AFI, AFI 99–103, covers capabilities T&E for all USAF systems. AFI 99–103 describes the planning, conduct, and reporting for T&E programs to ensure the testing is conducted in an efficient manner by combining test events when possible. This instruction does not refer to training system devices. The methods used for T&E must be applied to large training systems that fall within a certain acquisition category but do not cover any details about certification or qualification. This instruction covers the entire verification side of the systems engineering "V" model. The methods of test described in this instruction can be used during SIMCERT and SIMVAL.

5. Summary

The USAF has several instructions relating to aviation training system devices. The USAF has a well-documented instruction that describes the roles and responsibilities of every organization that compromises the management team. The AFIs provide

excellent guidance for training system managers to develop training system requirements and ensure the proper stakeholders are included. The AFIs list the required organizations who must participate in the training system device requirements generation phase. AFI 36–2251 provides instructions on how to document the management process, roles and responsibilities of the different USAF organizations, frequency of the required stakeholder meetings, the requirement to develop a SIMCERT and SIMVAL program, and the requirement to create a SIMCERT report.

Out of all the USAF AFIs, AFI 36–2251 provided the most information about certification or qualification for aviation training devices. This instruction provides a detailed plan for management but lacks specific details about the SIMCERT process. The instruction only mentions that all aviation training devices require a SIMCERT but does not provide the framework to prepare a SIMCERT plan, process to execute the SIMCERT plan, or the reporting content requirements after the completion of SIMCERT. The same is true for SIMVAL. Very little guidance was provided about the SIMVAL planning, execution, and reporting.

F. REVIEW OF EXISTING USA AVIATION TRAINING SYSTEM DEVICE GUIDANCE

1. Acquisition ARs

Similar to DON and USAF, the USA is required to follow the DoDI 5000.02 acquisition instructions. AR 350–38 is the USA overarching AR for managing TADSS. This AR provides the roles and responsibilities for the different team members within the Integrated Product Team (IPT) similar the USAF's AFI 36–2251. AR 350–38 describes TADSS as "System TADSS are designed and intended to train individual and/or collective tasks associated with a specific system, family of systems, or system of systems (SoS), for example, UH–60 Helicopters" (AR 350-38 2013, 1). This definition for training devices is the same as DON and USAF. The regulation describes the acquisition requirements for new TADSS. The same acquisition requirements are required in DoDI 500.02. AR 350–38 describes the purpose of training devices. It requires the acquisition team to improve and sustain USA readiness by providing state of

the art training to enhance training realism and to use very little or no munitions during training to reduce cost and required land for shooting ranges.

T&E is covered in Chapter 5–3, but does not describe any requirements for training device certification or qualification. The T&E scope is similar to the acquisition T&E requirements listed in DoDI 5000.02. The training device requires a Test and Evaluation Master Plan (TEMP) for large acquisition programs. The training device T&E results must be reported in accordance with Army Regulation 73–1 (AR 73–1) Test and Evaluation Policy. The required T&E strategy, execution, and reporting is required to comply with AR 73–1 and DoDI 5000.02. AR 350–38 does not require special certification or qualification results for training system devices. AR 73–1 does not mention training system devices within the AR. The entire document describes the test planning, execution, and reporting requirements process to comply with DoDI 5000.02. The AR did not describe any T&E process for training system devices.

2. Model and Simulation

AR 350–38 did not list any requirements for training system devices to follow Army Regulation 5–11 (AR 5–11), *Management of Army Models and Simulations* (2005), but it was listed as a requirement on Fort Rucker's website. Fort Rucker's Directorate of Simulation uses AR 5–11 as a guideline to VV&A TADSS (U.S. Army 2013).

AR 5–11 provides guidance for Simulation and Modeling for Acquisition, Requirements and Training (SMART) concept. The SMART concept aligns acquisition, and training communities through the use of M&S. This concept aligns the system acquisition with training early in the acquisition phase. It requires acquisition IPTs to consider M&S and training when developing acquisition strategies (AR 5-11 2005).

This regulation provides guidance on how to manage M&S for USA systems that include training systems. AR 5–11 does not specifically describe a special process for TADSS. The USA Directorate of Simulation serves as the accreditation agent for USA aviation training. Accreditation is part of the VV&A process and is covered in Chapter 5. AR 5–11 defines accreditation as an "official determination that the M&S is acceptable for its intended purpose" (AR 5-11 2005, 9). The VV&A process requires the test

management team to prepare an accreditation plan and report. The accreditation plan will identify the accreditation team; resources; milestones; required documentation; acceptable criteria; proposed accreditation methodology; Verification, Validation, and Certification (VV&C) approach. The report will include background information, description of M&S, VV&C results, analysis of V&V results to support accreditation, and limitations as they affect the M&S project's intended use. Chapter 5 did not list any specific VV&A or VV&C for aviation training devices (AR 5-11 2005).

3. Army Training Guidance

The last AR related to training devices is covered by Army Regulation 350–1 (AR 350–1), *Army Training and Leader Development* (2010). This AR prescribes the policies, procedures, and responsibilities for developing, managing, and conducting USA training and leadership development. AR 350–1 lists all the different USA organizations who are responsible for utilizing, managing, designing, and maintaining USA training material and devices This AR does not mention any process or requirement for TADSS certification or qualification.

4. Summary

USA ARs discuss the importance of training system devices for aviation training but do not provide a unique process for certification or qualification. The USA uses the M&S VV&A and VV&C process to qualify or certify their aviation training devices. The USAF and DON have an M&S instruction as well, but they do not refer to the M&S instruction for qualification or certification of aviation training devices. The USA training device certification and qualification is focused more on the M&S aspect of the system to determine if it is correctly modeling the system. The USA method is focusing on certifying the aviation training device is modeling the aircraft.

V. CONCLUSIONS AND RECOMMENDATIONS

A. GENERAL DISCUSSION

There are several instructions and different levels of guidance available on the subject of aviation training system device certification and qualification. The FAA, USAF, and DON have several different processes to perform aviation training system device certification or qualification. All the certification or qualification methods cover the core objectives discussed earlier to provide the user some methodical evidence that the training system device is capable of meeting the learning objectives. In other words, the goal of certification and qualification is to ensure that an aviation training system device, if used as designed, will result in improved performance of the trainee. However, it is the opinion of the author that the DoD acquisition community is not following their own processes for training system device certification or qualification. The training system requirements are not available prior to SRR-I. The training curriculum is never available at SRR-I and should be. The system design should follow the requirements including the curriculum.

Problems discovered with training systems today would not exist if the DoD training system device acquisition teams followed the existing guidance. An example is the problems discovered with the USN T-44A and Undergraduate Military Flight Officer (UMFO) training system devices. The requirements for T-44A were not consistent during the design phase which is critical to certification and qualification. A design baseline was not set by all the key stakeholders early in the acquisition program. The UMFO program should have provided the expectations of the system. The UMFO training devices did not match the user's expectations when it was first delivered. The UMFO instructors expected the training device to operate like the T-45C but it was not documented as a requirement. The problems discovered with the UMFO training system device could have been discovered during the certification or qualification phase prior to delivery to the customer. The certification and qualification process tests the training system device to the requirements. The stakeholders are involved during the requirements and test phases. The certification and qualification process is defined during the requirements generation

process. This process enables the stakeholders to revise the requirements to include any missed requirements when the certification or qualification plan is drafted. All of these issues could have been avoided if the existing process was followed. There are very few issues published about the FAA training device qualification methods with respect to training objectives because they follow its processes.

There are issues noted with DoD training systems, based upon the author's experience, with training system acquisitions. Unfortunately, most of the lessons learned have not been published or documented to educate other training system device acquisition teams. There are a few teams that have followed the START process to improve the quality of the training system by performing post-delivery modifications. However, as TDCAP suggests these issues should have been corrected during the design phase.

Given today's news headlines, it is likely that most training system acquisitions are facing scrutiny over budgets and acquisition timelines. Most of the processes identified in this thesis are described as separate processes outside of the typical acquisition SE process. Certification is part of the SE process and should be included in the acquisition strategy, not as a separate process that can be easily removed when schedules and budgets are challenged. The method of qualifying a training system device is not different from qualifying any other product that has the purpose to meet a user's need and should be treated as such. It is the author's opinion that the next DoD training system acquisition should incorporate the processes described in this thesis for certification or qualification and modify the existing guidance if there are any lessons learned. The acquisition team should not follow a certification or qualification method just because it exists. The team should apply critical thinking to ensure the certification or qualification process meets the original requirement. This provides evidence that the training device meets the original learning objectives for T&R. It is the author's opinion that if the acquisition team can accomplish this, the certification or qualification process cannot be separated during program execution when budgets and schedules are challenged.

B. CONCLUSIONS

1. Stakeholders, Requirements, and Certification

This thesis answered the following research questions:

What is the benefit to developing a certification and qualification process? Can it be quantified?

Aviation system device certification and qualification is an important phase within the T&E systems "V" model. Certification or qualification provides evidence to the users that the system as designed meets the original training goal. The training system device is a correct representation of the aircraft platform it was designed for. The USN, USMC, USAF, and USA, have different approaches to certify or qualify aviation system training devices. Although the techniques differ, they all meet their original certification or qualification intent, to model the aircraft, or to ensure the system is acceptable to provide training. A successful aviation training system requires the services to develop good requirements to ensure the aviation training system training goals are well understood by all the stakeholders.

The DON uses a combination of aviation training devices and aircraft to provide T&R. Flying in an aircraft for training is very costly. It is more cost effective to use a training device for training than an aircraft. As a result, USN and USMC are interested in looking at using more aviation training system devices to provide more T&R credit than the aircraft. The USN START process maps all of the learning objectives to T&R events.

What were the stakeholder's requirements for the training systems? How are the requirements specified, and how are they subsequently used in the development process?

The USAF training system management process is well documented. The USAF process provides guidance to ensure all the training system stakeholders are involved early in the acquisition process. This method would ensure all the stakeholder's requirements for the new aviation training system are well understood. The DON, USN and USMC describe an upfront FEA analysis but do not describe the method to ensure all the proper DON stakeholders are involved during the upfront requirements generation process or through the design phase. This process could be overlooked during the team formation or requirements generation phase for training systems. The USAF does not

provide a lot of detail for certification or qualification for training devices but its policy requires SIMCERT to be performed. It is the author's recommendation that the USN certification process be revised to include the USAF requirements generation process and the DON certification process. The USAF has a well-documented instruction that describes the roles and responsibilities of every organization that compromises the management team. The AFIs provide excellent guidance for training system managers to develop training system requirements and ensure the proper stakeholders are included. The USN and USAF certification process is not sufficient to meet the USN certification requirements individually. The USN TDCAP lacks requirements generation guidance.

USN TDCAP is applied during the acquisition process. TDCAP is included in the planning, requirements generation (steps to SRR I), system design (steps to CDR), and T&E. The USN and USAF certification processes should be combined to meet the USN stakeholders' requirements for training system certification or qualification.

The FAA has a well-documented process for training system certification or qualification. However, the FAA does not provide guidance to the developer about what level of “realism” is adequate for meeting the learning objectives. The most realistic aviation training system is Level D, however, that is also the most costly training system to develop. A lower Level simulator might be adequate to accomplish the learning objectives. The FAA developed a certification and qualification process for the training system to match the capabilities of the aircraft it was simulating.

2. Certification Documentation

This thesis researched several different military, commercial, and federal agencies to develop a list of existing certification and qualification processes.

What organizations currently have a training system certification and qualification process? Are there any well accepted "best practices" in the industry?
Why did the organization develop a certification and qualification process?

There is an overwhelming amount of information available about aviation training systems management, acquisition, design, engineering, and testing. The USN has a lot of instructions and guidance currently available to create a certification or qualification plan

for new or existing aviation training system devices. The USN TDCAP and START processes are achieving the same goal by analyzing existing aviation training system devices to determine what learning objectives or T&R events can be met. The two processes also quantify the capability of the aviation training device to meet the learning objectives or T&R events. TDCAP is structured and organized similar to a functional decomposition for a system. In this particular process, the goal is to teach "learning objectives," the functions are the different "tasks," and the forms are the "attributes."

The FAA ACs were created to ensure the aviation training system met the requirements for training. The need to create an aviation training device certification and qualification process was required after the FAA allowed training system devices to be used to log flight training time. Each FAA aviation training device AC is organized according to aircraft type.

The USAF has several instructions relating to aviation training system devices. AFI 36–2251 provided the most information about certification or qualification for aviation training devices. This instruction provides a detailed plan for management but lacks specific details about the SIMCERT process. The instruction only mentions that all aviation training devices require a SIMCERT but does not provide the framework to prepare a SIMCERT plan, process to execute the SIMCERT plan, or the reporting content requirements after the completion of SIMCERT.

After a considerable amount of literature research, it is a safe assumption to conclude that there is no USA specific policy or guidance for training system certification or qualification.

What is an acceptable reporting process for the certification process?

The final product of the USN TDCAP is a results report. The report summarizes the aviation training device's capability to meet the necessary learning objectives, T&R events, and training tasks associated with the training goal. Ultimately, the report could be available to the decision-makers to determine if the aviation training device should be added to the list of approved aviation training devices.

The USAF provides the stakeholders a SIMCERT report. The SIMCERT report provides the stakeholders an assessment of the capabilities and limitations of the aviation training system. The results of SIMCERT provide an audit trail for training effectiveness and quality assurance.

What are the tradeoffs for not completing all of the recommended test events for certification? What is the true "return on investment" made in certification and qualification process?

The training device would not be certified for certain learning objectives if the training device is not fully tested. The learning objectives would need to be accomplished in the aircraft. The cost savings by using a training system device instead of an aircraft could easily be developed with cost data. This thesis does not quantify the potential cost savings but recommends further research on the cost for taking a T&R event credit in an aircraft versus an aviation training system device. This analysis requires additional time and cost data.

C. RECOMMENDATIONS

Through analysis of all the existing training system device certification and qualification processes, the following recommendations for USN certification or qualification process are suggested to address the weaknesses listed in the conclusions.

1. Provide guidance for training system device requirements generation. Recommend listing all the necessary stakeholders' roles and responsibilities for developing training system device goals, functions, and design limitations to include required equipment. This will ensure the proper stakeholders are involved.

2. Ensure the FEA analysis and the USN users are involved through the entire training system device acquisition process, from requirements generation to certification or qualification. This will help provide testable requirements during the certification process.

3. Develop or use an existing requirements tractability tool to ensure the design meets the original learning objectives or required skills. This method will help during the certification or qualification phase to show the impact of any deficiencies discovered during T&E.

4. Include a process to include FEA authors during the design and test phases. TDCAP describes the FEA traceability through the system specification and RTVM but does not describe the process to involve the USN users through the

design process. This will help define requirements and avoid potential requirements creep.

5. Recommend USN develop a process to add aviation training devices to OPNAVINST 3710.7U. This will avoid potential inconsistencies for adding training system devices to the approved list.

6. Include a section in TDCAP that describes how the process complies with the DoDI 5000.02 process but tailored to training system devices. All the other services provide this link in their instructions to show traceability back to DoDI 5000.02. This will help show tractability to the overarching DoD SE process.

7. Include the TDCAP as part of the acquisition strategy for training system device acquisition. Do not describe TDCAP as a separate process but identify how TDCAP will meet the DoDI 5000.02 and SECNAVINST 5000.2E requirements for SE for training system design, procurement, and test. This will help training system acquisition programs justify the certification process.

8. Follow the existing TDCAP guidance for one project then correct the process to meet the original intent of TDCAP without creating a new process with a different name but same goals. The START and TDCAP process are very similar but can be confusing with different names.

9. Provide a method to train the NAWCTSD workforce about TDCAP and the similarities to systems engineering. This will help the workforce understand the relationships between the learning objectives and the system design.

10. Develop a T&E tool similar to a requirement traceability tool but link any deficiencies discovered during certification or qualification testing back to the original learning objective. This will help the program manager understand the impact to the learning objective.

D. AREAS FOR FURTHER RESEARCH

This thesis analyzed published instructions and guidance about certification or qualification for training devices. Areas of possible future research would include:

1. Contact each service to determine what agency is responsible for conducting certification or qualification for training devices. Ask the agency if there is any existing guidance for conducting certification or qualification that is not covered in a published instruction.

2. Conduct a USN case study on a training device system to include requirements generation, design, test, and fielding, to determine areas of improvement for TDCAP.

3. Investigate cost benefits from transferring training from the aircraft to the aviation training device. Include benefits or impacts to the learning objective by using the aviation training device instead of the aircraft.

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